UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

February 11, 1999

MEMORANDUM

SUBJECT: Review of Poison Control Center Data for Residential Exposures to Organophosphate Pesticides, 1993-1996
DP Barcode 253361, Reregistration Case #0100

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I. INTRODUCTION

Most of the nation's Poison Control Centers (PCCs) participate in a national data collection system, now known as the Toxic Exposure Surveillance System (TESS). Some 64-67 Centers at hospitals or universities participated from 1993 through 1996 (Litovitz et al. 1994-1997). PCCs provide telephone consultation for individuals and health care providers, 24 hours a day/365 days a year. Typically they serve a population of 1 to 10 million people and receive a minimum of 10,000 calls per year (Felberg et al. 1996).

The current review is based on 424,469 records of pesticide-related exposures (excluding cases exposed to multiple products, attempted suicides, malicious intent, and confirmed non-exposures) reported to Poison Control Centers participating in TESS from 1993 through 1996. Of the 424,469 exposures, 392,188 occurred in a residential setting and 62,915 of these (16%) were due to organophosphate pesticides.

II. DETAILED DESCRIPTION OF POISON CONTROL CENTER METHODOLOGY

This section describes Poison Controls Centers operation and their nationwide system of data collection. The use of a standardized form for data collection, definition of key data elements, and quality assurance procedures used by the American Association of Poison Control Centers (AAPCC) are outlined.

Poison Centers receive telephone calls from individuals and health care providers seeking information on how to manage an exposure to a poison. Typically the Poison Center itself is run by a hospital or university. "Poison Centers function primarily to provide poison information, telephone management and consultation, collect pertinent data, and deliver professional and public information" (AAPCC 1988). Each center must have a poison information specialist available on site at all times. Written operational guidelines must be used to assure a consistent approach to the handling of all poison exposures. Included in the guidelines must be provision for follow-up of each case to determine patient's final disposition or medical outcome.

Participating Poison Control Centers must have a board certified physician on call with medical toxicological expertise. The calls are initially handled by a poison information specialist who has been trained and certified by examination. Approximately 13% of their calls come from doctors treating exposed patients. The other 87% come from victims of the exposure or their relatives (e.g., mother of an exposed child). Regular case reviews and audits are scheduled to assure quality assurance of the data collected. Records kept on all cases must have sufficient narrative to permit review.

The Poison Centers participating in the Toxic Exposure Surveillance System (formerly the National Data Collection System) complete a form or computer record describing each case that contains standard data elements and a narrative section. Information collected includes the date of call, age and sex of the victim, location of victim at time of exposure (e.g., home, work place), substance exposed to, route of exposure, initial symptom assessment, treatment received (e.g., referred to physician, hospitalized), and an evaluation of medical outcome after case follow up. Starting in 1993 information about specific symptoms reported was also collected. Data are then sent to the AAPCC for processing (AAPCC 1988).

Patients treated at home or any other non-health care site are classified as "managed on site" (Interpretation of the AAPCC Data, AAPCC 1994). Those seen in a health care facility may be classified as either treated and released or admitted for medical care. "Admitted for medical care" is used when "the patient is observed and/or treated and subsequently admitted as an inpatient primarily to receive medical care rather than psychiatric evaluation".

When symptoms or signs occur they are categorized into minor, moderate, or major depending on their severity and whether recovery is complete. Definitions used by the Poison Control Centers to categorize medical outcome are given in summary form below (Veltri et al. 1987).

Minor: Minimal symptoms or signs with no residual disability (e.g., mild gastrointestinal symptoms, skin irritation, drowsiness).

Moderate: Symptoms or signs are more pronounced, prolonged, or more of a systemic nature than minor symptoms with no residual disability. Usually some form of treatment is indicated. Examples include: high fever, disorientation, hypotension which rapidly responds to treatment and isolated brief seizures.

Major: Symptoms or signs are life-threatening or result in residual disability or disfigurement. Examples include patients who require intubation plus mechanical ventilation, who sustain repeated seizures, cardiovascular instability, or coma.

Data quality issues

Validity of the data collected by different poison centers is an important concern of the Toxic Exposure Surveillance System. Some 60-70 Centers staffed by six or more personnel each are responsible for collection of the information on each case, properly coding the information and submitting it to the AAPCC which maintains the national database. Reporting by individual PCCs is dependent on how well their service is known and advertised.

Poison Centers collect data on each call they receive and transfer the information to the Toxic Exposure Surveillance System. The AAPCC conducted an audit of 588 randomly-selected pesticide charts based on records submitted to the TESS in 1996 (AAPCC 1998). Thirty-four cases were excluded from a Center that was over-represented in the data set and another 24 cases were excluded because of three Centers that had closed since 1996. After these exclusions, requests for 530 cases were sent to the PCCs and 512 records were located and returned to the AAPCC for a response rate of 96.6%. Thirteen records could not be located, one Center did not send the three requested records, and the wrong record was sent in two cases. Cases were reviewed to determine how accurately the information coded in TESS matched the information in the original medical record. Five fields important to this analysis were selected for the audit: reason for exposure, route of exposure, management site of case, medical outcome, and accuracy of specific and generic substance category.

Results from the audit found the majority of cases were coded correctly (AAPCC 1998). Of those cases that did contain errors, the most common error was insufficient follow-up to accurately code the flow of patient care or medical outcome. Reason for exposure was coded correctly 90.4% of the time, incorrectly coded in 4.5%, and insufficient information to determine coding in 5.1%. Route of exposure was coded correctly in 95.9% of cases and incorrectly coded in 3.7% (1.7% incorrect route and 2.0% route(s) omitted). Health care facility use and referral was correctly coded for 93.5%, incorrect in 1.8%, and unable to determine correct coding in 4.7%. Outcome was correctly coded in 82.8%, coded incorrectly in 5.1%, and unable to determine correct coding in 12.1% (due to inadequate follow-up or missing information). Substance was correctly coded 93.3% of the time, incorrectly coded 6.5%, and unable to determine if correct 0.2%. Generic code was coded correctly 98.1% of the time and incorrectly coded 1.7% of the time.

Many poisoning cases seen in emergency rooms or by private physicians do not result in calls to a PCC. A study of all acute care hospitals in Utah compared all inpatient and outpatient records of poisoning with calls to the Poison Center serving Utah and found that only about one-third of the cases matched (Veltri et al. 1987). Characteristics of unmatched cases were not studied so it is not possible to say how PCC cases might differ from hospital cases that do not result in a call to a PCC.

The use of a standard format by different Poison Centers with standard definitions for each data element means that studies can be done using two or more centers (Veltri et al. 1987). The voluntary nature of the PCC system means that not all exposures to poisons are reported in any given catchment area served by the PCC. The extent of under-reporting is not known. More importantly, it is not known whether or how reported cases differ from unreported cases. Thus, any study using PCCs as a source for cases can only be judged representative of the universe of exposures reported to PCCs and not the entire universe of all poison exposures. PCC data is a simple form of a case series and therefore is not appropriate for complicated statistical analysis. However, given the large proportion of the U.S. population served by PCCs participating in the TESS (70-87%) and the large number of poison exposures, factors identified within this selected series are likely to be helpful for targeting particular types of exposure situations for risk mitigation.

Each Poison Center must keep records on all cases handled by the Center in a form that is acceptable as a medical record (AAPCC 1988). The standardized form or computer record that is used must contain all data elements filled out and sufficient narrative to permit peer review and medical or legal audit. The data must be submitted to the AAPCC's Toxic Exposure Surveillance System within deadlines and meet quality requirements as specified in guidance of the AAPCC.

Most of the cases submitted to the Toxic Exposure Surveillance System come from certified Poison Control Centers. To be certified a PCC must fulfill the following criteria (AAPCC 1988):

1. Have a board certified physician on-call at all times with expertise in medical toxicology.
2. Have poison specialists available to handle all calls. These specialists are required to complete a training program and are certified by the AAPCC.
3. Maintain a comprehensive file of toxicology information sources and have ready access to a major medical library.
4. Maintain operational guidelines which provide a consistent approach to evaluation and management of toxic exposures.
5. Have an ongoing quality assurance program including regularly scheduled conferences, case reviews and audits.
6. Keep records on all cases handled by the Center with data elements and sufficient narrative to allow for peer review.
7. Submit all case data to the Toxic Exposure Surveillance System, meet deadlines and quality requirements and include all required data elements. Taken together all these criteria help assure the quality of the data.

Examination of AAPCC annual reports from 1993 through 1996 found that 7 states had little or no coverage during that period (Litovitz et al. 1994-1997). They were Arkansas, Illinois, Maine, Mississippi, Oklahoma, South Carolina, and Vermont. Another 5 states (Iowa, Minnesota, Nevada, North Carolina, and Texas) had little or no coverage for one or two of the four years. Of the 81 organophosphate-related deaths reported from 1979 through 1992, 34% occurred in these 12 states that did not consistently report to the TESS (CDC 1997). Thus, cases of poisoning are under-represented in AAPCC data. Estimated proportion of the U.S. population served from 1993 to 1996 ranged from 70% to 87%, with an average of 81%.

Over-reporting may also occur when symptoms are reported over the phone which cannot be confirmed by a physician or laboratory tests for exposure or effects. Though about 13% of cases are referred to the PCC by a physician, the majority involve a phone call from the victim or relative. Poison Specialists must rely on their experience and judgment to determine which cases have symptoms consistent with the toxicology, dose, and timing of the exposure. While some misclassification can be expected to occur from this approach, it is not expected to be differentially biased among pesticides. That is, there is no reason to believe that Poison Specialists are likely to misclassify one organophosphate more or less than another.

III. RESULTS

Results are presented below in tabular form for thirteen organophosphate insecticides for which there were at least 100 exposures each in a residential setting. Table 1 presents the number of cases reported by year for each chemical.

Table 1. Number of unintentional* residential exposures reported to PCCs, 1993-1996 (Includes only exposures to single products).

PESTICIDE	1993	1994	1995	1996	Total
ACEPHATE	336	446	417	376	1575
CHLORPYRIFOS	3512	4521	4888	4850	17,771
DDVP	1190	994	1481	1682	5347
DIAZINON	2818	3026	2983	2981	11,808
DIMETHOATE	82	72	78	67	299
DISULFOTON	154	167	134	115	570
FENTHION	74	75	73	48	270
MALATHION	1288	1426	1231	1277	5222
NALED	53	38	25	33	149
OXYDEMETON METHYL	42	31	22	21	116
PHOSMET	347	336	302	267	1252
PROPETAMPHOS	54	58	53	34	199
TETRACHLORVINPHOS	199	199	207	199	804
SUBTOTAL	10,149	11,389	11,894	11,950	45,382
OTHER IDENTIFIED ORGANOPHOSPHATES	673	500	620	539	2332
ORGANOPHOSPHATES NOT IDENTIFIED	660	4104	5296	5141	15,201

TOTAL ALL ORGANOPHOSPHATES	11,482	15,993	17,810	17,630	62,915

* Unintentional exposures includes 416 cases of intentional misuse, 109 cases of contamination or tampering, and 870 cases categorized as adverse reactions.

The apparent increase in number of organophosphate exposures reported to Poison Control Centers is largely explained by the increased participation of states in later years. The data for 1994-1996 includes representation of PCCs covering most of Texas, Iowa, and Minnesota, which were not covered in 1993. Similarly, North Carolina is largely included in 1995-1996 but not 1993-1994. A sharp jump in the number of unidentified organophosphates (Centers coded the general organophosphate category, but not the specific product), makes it difficult to determine whether there were any significant trends over the 1993-1996 time period.

Table 2. Number of unintentional residential exposures reported to PCCs, 1993-1996, by age class* (exposures to multiple products excluded).

PESTICIDE	Adult	Child under 6	6-19 years	Total
ACEPHATE	1091	348	117	1556
CHLORPYRIFOS	7227	8998	1335	17,560
DDVP	2365	2345	597	5307
DIAZINON	6402	4253	996	11,651
DIMETHOATE	217	44	34	295
DISULFOTON	282	236	40	558
FENTHION	174	64	28	266
MALATHION	3214	1352	583	5149
NALED	46	89	14	149
OXYDEMETON METHYL	83	19	11	113
PHOSMET	639	470	133	1242
PROPETAMPHOS	114	63	19	196
TETRACHLORVINPHOS	215	495	86	796
SUBTOTAL	22,069	18,776	3,993	44,838

OTHER IDENTIFIED ORGANOPHOSPHATES	1152	927	220	2299
ORGANOPHOSPHATES NOT IDENTIFIED	8866	5186	867	14,919
TOTAL ALL ORGANOPHOSPHATES	32,087	24,889	5,080	62,056

* Totals differ from those in Table 1 slightly because those cases with unknown age class are excluded from this table.

Of the 13 organophosphates identified in Table 2, 90% of the exposures reported in children under age six were due to just four organophosphates: chlorpyrifos (48%), diazinon (23%), DDVP (12%), and malathion (7%). The same four compounds accounted for 87% of the adult exposures: chlorpyrifos (33%), diazinon (29%), malathion (14%), and DDVP (11%). Children under age six accounted for 40% of all organophosphate exposures and more than half of the exposures to chlorpyrifos (51%), naled (60%), and tetrachlorvinphos (62%).

Several measures of hazard were developed based on the Poison Control Center data. The first measure chosen was the percentage of all accidental cases that were seen in or referred to a health care facility (HCF). The second measure was the percent of these cases (seen in or referred to a HCF) that were admitted for medical care. Typically, cases are not admitted unless the attending physician feels the case is likely to require extensive treatment to prevent further adverse effects. A third measure selected was the number of cases reporting symptoms or signs based just on those cases where the medical outcome could be determined. The fourth measure selected was the percentage of those cases that had a major medical outcome, defined as life-threatening or resulting in residual disability, or a fatality.

Table 3 summarizes these measures for children under six years of age. Table 4 provides the same information for adults and children 6-19 years old. In each table shading has been used to indicate measures based on a relatively small sample of less than 25 cases (in the denominator). The top 3 ranking chemicals for any one measure is indicated by an superscript of 1-3. Another measure of hazard, related to hospitalization, is admission for critical care (intensive care unit or ICU). Table 5 provides the data for both children and adults. Note that several chemicals could not be measured reliably in children because of the relatively small number of cases.

A primary measure of hazard is the incident rate defined as the number of individuals who become ill divided by the number at risk over some time period. Tables 3-5 look at proportionate hazard which is one way of ranking pesticides by their potential for causing problems. Another method is to develop a surrogate measure for the population at risk by estimating the extent of pesticide use in residential households. The EPA survey of home and garden pesticide use provides estimated number of containers and applications of pesticides for all households in the United States in 1990 (Whitmore et al. 1992). Table 6 takes all of the reported symptomatic cases in young children and adults/older children and estimates the rate of poisoning (cases defined as minor, moderate, major, or fatal outcome) per million containers and per million applications in U.S. homes. The purpose of this analysis is to determine whether widespread use rather than some factor is responsible for a high hazard ranking.

Tables 7 and 8 look at two additional measures of pesticide hazard. Table 7 looks at just those cases due to pesticide residue or contamination rather than direct spill or accidental ingestion. This is because different risk mitigation factors are needed when a pesticide is found to be a risk due to environmental exposure where the victim does not have the pesticide under their direct control. For example, certain uses might be restricted to certified applicators or a reentry period might required before residents are permitted back into treated structures.

Table 3. Percent residential cases seen in or referred to a health care facility (HCF), percent hospitalized (of those seen in a HCF), percent with related symptoms (where outcome was known), and percent with major (life-threatening or residual disability) or fatal medical outcome for children under age six, PCCs 1993-1996. (Percents in shadow are not reliable, denominator less than 25).

PESTICIDE	% seen in a HCF	% Hospit-alized	% with symptoms	% major or fatal
ACEPHATE	14.4	6.0	21.8	0.0 (0)
CHLORPYRIFOS	11.0	12.6	19.9	0.3 (12)
DDVP	9.9	10.7	23.4[3]	0.2 (2)
DIAZINON	18.1	16.6	20.8	0.6[3] (16)
DIMETHOATE	22.7[3]	50*[1.5]	21.7	0.0 (0)
DISULFOTON	9.7	21.7	8.2	1.4[2] (2)
FENTHION	15.6	20.0	8.3	0.0 (0)
MALATHION	18.3	16.1	20.9	0.5 (4)

NALED	11.2	10.0	21.3	0.0 (0)
OXYDEMETON METHYL	10.5	50*[1.5]	8.3	0.0 (0)
PHOSMET	43.4*[1]	22.0[3]	24.6[2]	0.0 (0)
PROPETAMPHOS	30.2[2]	10.5	34.4[1]	3.1[1] (1)
TETRACHLORVINPHOS	4.8	8.3	20.9	0.0 (0)
MEDIAN FOR 13	14.4	16.1	20.9	0.0
MEAN ALL OPs	12.7	15.2	23.0	0.4 (46)
MEAN NON-OPs	17.8	4.6	22.0	0.1 (108)

Top 3 chemicals are ranked with a superscript of 1 to 3.
* Indicates a statistical outlier.

Children exposed to organophosphate pesticides are somewhat less likely to be seen in a health care facility than children exposed to other non-organophosphate pesticides. However, once in a health care facility, children are three times more likely to be hospitalized if exposed to organophosphates than if not. They are also nearly four times more likely to have experienced a major medical outcome or death. The two most widely used organophosphate pesticides in residential settings, chlorpyrifos and diazinon, had three and six times, respectively, more major or fatal cases than non-organophosphates. These data strongly support the finding that organophosphates pose a much greater risk of severe poisoning in young children than do other pesticides.

Table 4. Percent residential cases seen in or referred to a health care facility (HCF), percent hospitalized (of those seen in a HCF), percent with related symptoms (where outcome was known), and percent with major (life-threatening or residual disability) or fatal medical outcome for adults and children 6-19 years old, PCCs 1993-1996. (Percents in shadow are not reliable, denominator less than 25).

PESTICIDE	% seen in a HCF	% Hospit-alized	% with symptoms	% major or fatal
ACEPHATE	21.4[2]	8.9	68.1	0.0 (0)
CHLORPYRIFOS	20.6	9.5	74.6[3]	0.4[1] (18)
DDVP	14.7	7.6	68.6	0.0 (0)
DIAZINON	20.3	10.8	67.7	0.3[2] (10)
DIMETHOATE	20.7[3]	7.7	66.1	0.0 (0)

DISULFOTON	14.0	13.3[3]	54.1	0.0 (0)
FENTHION	12.9	15.4[1]	60.4	0.0 (0)
MALATHION	17.4	10.4	60.8	0.3[3] (5)
NALED	20.0	0.0	80.8*[1]	0.0 (0)
OXYDEMETON METHYL	13.8	7.7	60.0	0.0 (0)
PHOSMET	25.4[1]	13.8[2]	65.0	0.0 (0)
PROPETAMPHOS	13.5	0.0	76.3[2]	0.0 (0)
TETRACHLORVINPHOS	13.0	2.6	68.6	0.0 (0)
MEDIAN FOR 13	17.4	8.9	67.7	0.0
MEAN ALL OPs	17.9	9.9	69.5	0.3 (49)
MEAN NON-OPs	17.6	6.6	70.7	0.3 (160)

Top 3 chemicals are ranked with a superscript of 1 to 3.
* Indicates a statistical outlier.

Organophosphates and non-organophosphates show a similar pattern of health care facility use, development of symptoms (including major outcome and fatality) among adults and older children. However, adults seen in a health care facility are 50% more likely to be admitted or hospitalized if exposed to an organophosphate pesticide than a non-organophosphate pesticide. Table 5 provides information on admission to critical care for both children and adults. The information in Tables 3-5 are presented as bargraphs in Figures 1 and 2.

Table 5. Percent residential cases admitted for critical care (as a proportion of those seen or referred to a health care facility), for children under age six and adults and children 6-19 years old, PCCs 1993-1996. (Percents in shadow are not reliable, denominator less than 25).

PESTICIDE	Cases admitted for critical care			
	Children under 6		Adults/children 6+	
	number	percent	number	percent
ACEPHATE	1	2.0%	9	3.5%
CHLORPYRIFOS	55	5.5%	66	3.8%
DDVP	7	3.0%	12	2.8%

DIAZINON	56	7.3%[2]	81	5.4%
DIMETHOATE	3	30%	3	5.8%
DISULFOTON	3	13%	4	8.9%[2]
FENTHION	0	0%	3	11.5%[1]
MALATHION	17	6.8%[3]	35	5.3%
NALED	0	0%	0	0%
OXYDEMETON METHYL	0	0%	1	7.7%[3]
PHOSMET	21	10.3%[1]	13	6.6%
PROPETAMPHOS	1	5.3%	0	0%
TETRACHLORVINPHOS	0	0%	1	2.6%
MEDIAN FOR 13	164	5.3%	228	5.3%
MEAN ALL OPs	209	6.6%	313	4.7%
MEAN NON-OPs	444	1.17%	547	2.72%

Top 3 chemicals are ranked with a superscript of 1 to 3 for the percent of cases seen in or referred to a health care facility that were admitted to the intensive care unit.

Exposures to organophosphates are more likely to lead to treatment in an intensive care unit than are other pesticides. There were a total of 209 children under age six and 313 adults and children aged 6-19 years old treated in an ICU for residential exposure to an organophosphate pesticide from 1993 through 1996. For children under age six, they are over five times more likely to be admitted to an ICU if exposed to an organophosphate pesticide. For adults and children 5-19 years old, they are nearly twice as likely to require care in an ICU if exposed to an organophosphate.

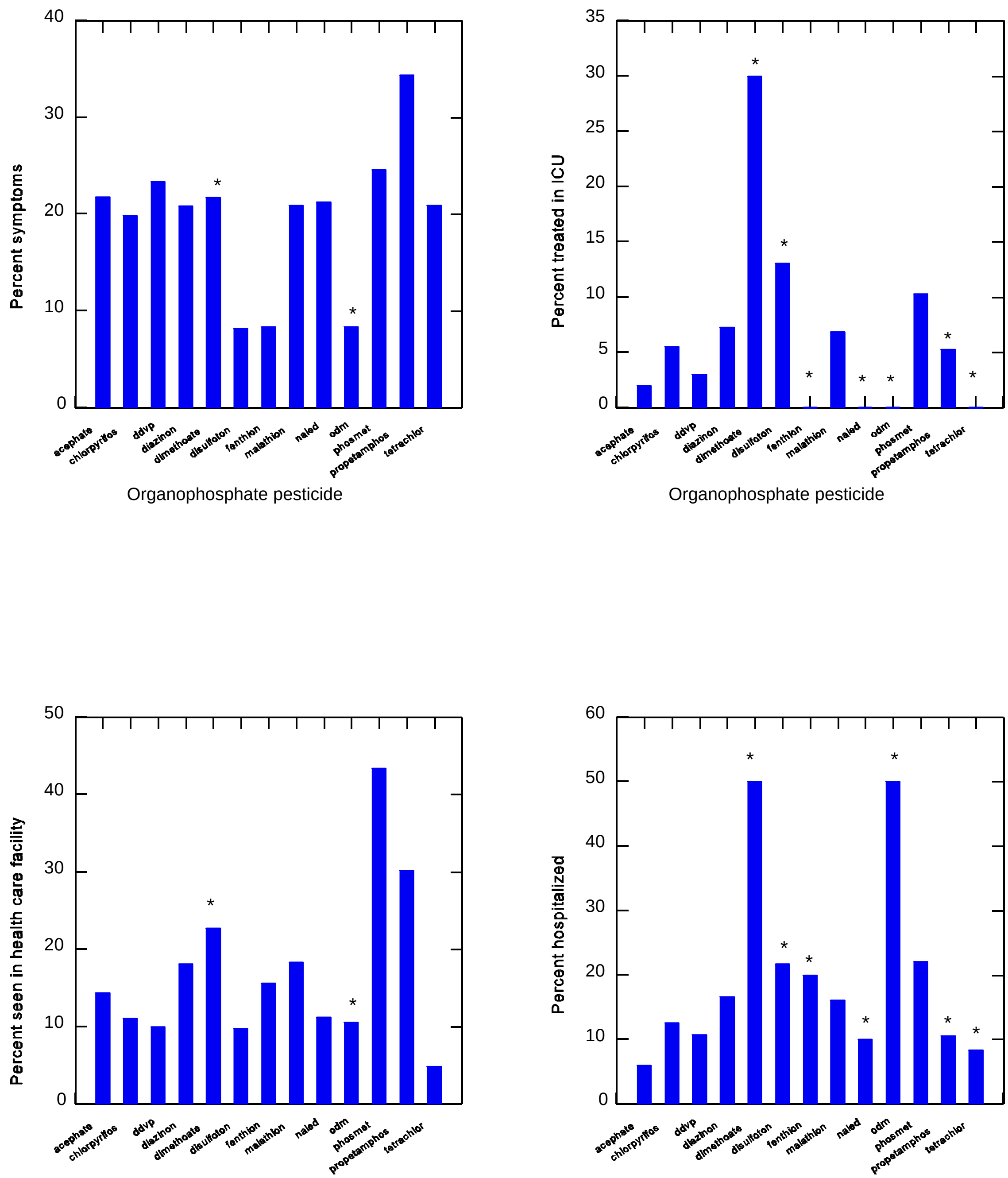

Figure 1. Child bargraphs of percent cases seen in health care facility, percent hospitalized, percent symptoms, and percent treated in ICU (* indicates too small sample size to be reliable). Based on Tables 3 and 5.

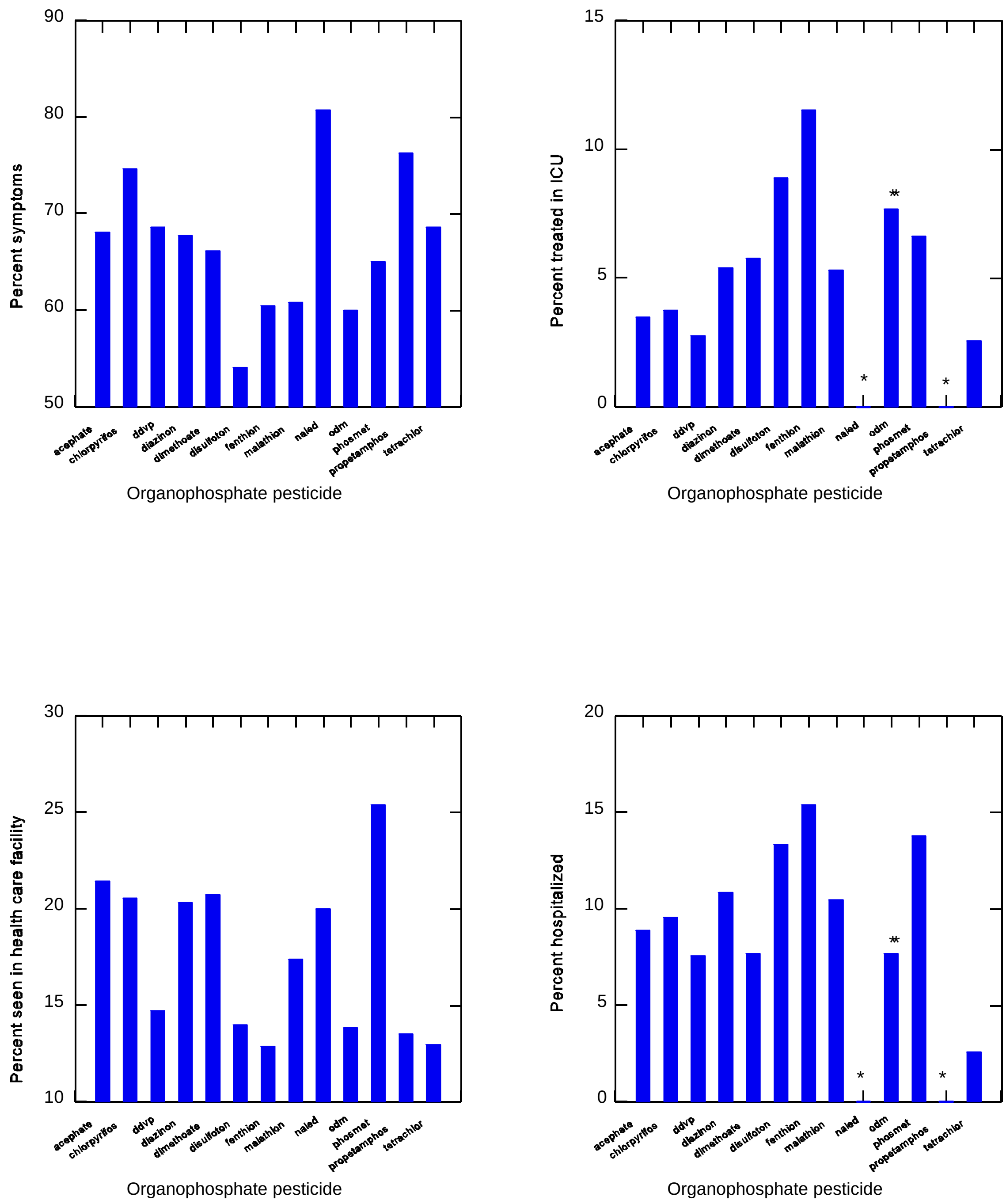

Figure 2. Adult bargraphs of percent seen in health care facility, percent hospitalized, percent symptoms, percent treated in ICU (* indicates too small sample size to be reliable). Based on Tables 4 and 5.

Table 6. Ratio of residential symptomatic cases (outcome determined, average per year for 1993-1996) per million containers and per million applications in U.S. homes in 1990 for children five years and under and adults and children older than five years. (Ratios in shadow are not reliable, based on 25 or less cases).

PESTICIDE	CHILD SYMPTOMATIC CASES PER USE		ADULT SYMPTOMATIC CASES PER USE	
	MILLION CONTAINERS	MILLION APPLICA-TIONS	MILLION CONTAINERS	MILLION APPLIC A-TIONS
ACEPHATE	2.3	0.4	21.6	3.9
CHLORPYRIFOS	12.9[3]	1.0	44.2[3]	3.4
DDVP	7.8	1.0	24.2	3.0
DIAZINON	8.3	1.8	38.5	8.1
DIMETHOATE	4.2	9.5[3]	69.8[2]	159.1[1]
DISULFOTON	1.3	0.5	7.7	2.8
MALATHION	4.3	2.2	29.1	14.6
NALED*	15.8[2]	12.7[2]	33.2	26.6[3]
OXYDEMETON METHYL	0.2	0.4	7.3	10.5
PHOSMET	60.0[1]	42.5[1]	189.4[1]	134.1[2]
TETRACHLORVINPHOS	5.8	0.8	10.8	1.5
MEDIAN FOR 11 OPs	5.8	1.0	29.1	8.1
MEAN ALL OPs	11.2	1.6	43.7	6.3

Top 3 chemicals are ranked with a superscript of 1 to 3.
* Estimates of naled use in the home are unreliable.

Table 6 compares the number of symptomatic cases, those cases with a medical outcome of minor, moderate, major, or fatal, with the estimated use in households in 1990. Fenthion and Propetamphos did not have any significant use reported in the 1990 survey of home and garden pesticide use. Both pesticides are applied mainly by professional applicators, especially fenthion which is used primarily for mosquito abatement. This table shows that the problems suggested in earlier tables for phosmet are not simply due to the widespread use. Phosmet ranked highest for three out of the four ratios in table 6. Dimethoate also ranked at or near the top, especially for adults. Tables 3 had suggested that dimethoate was more of a problem for children.

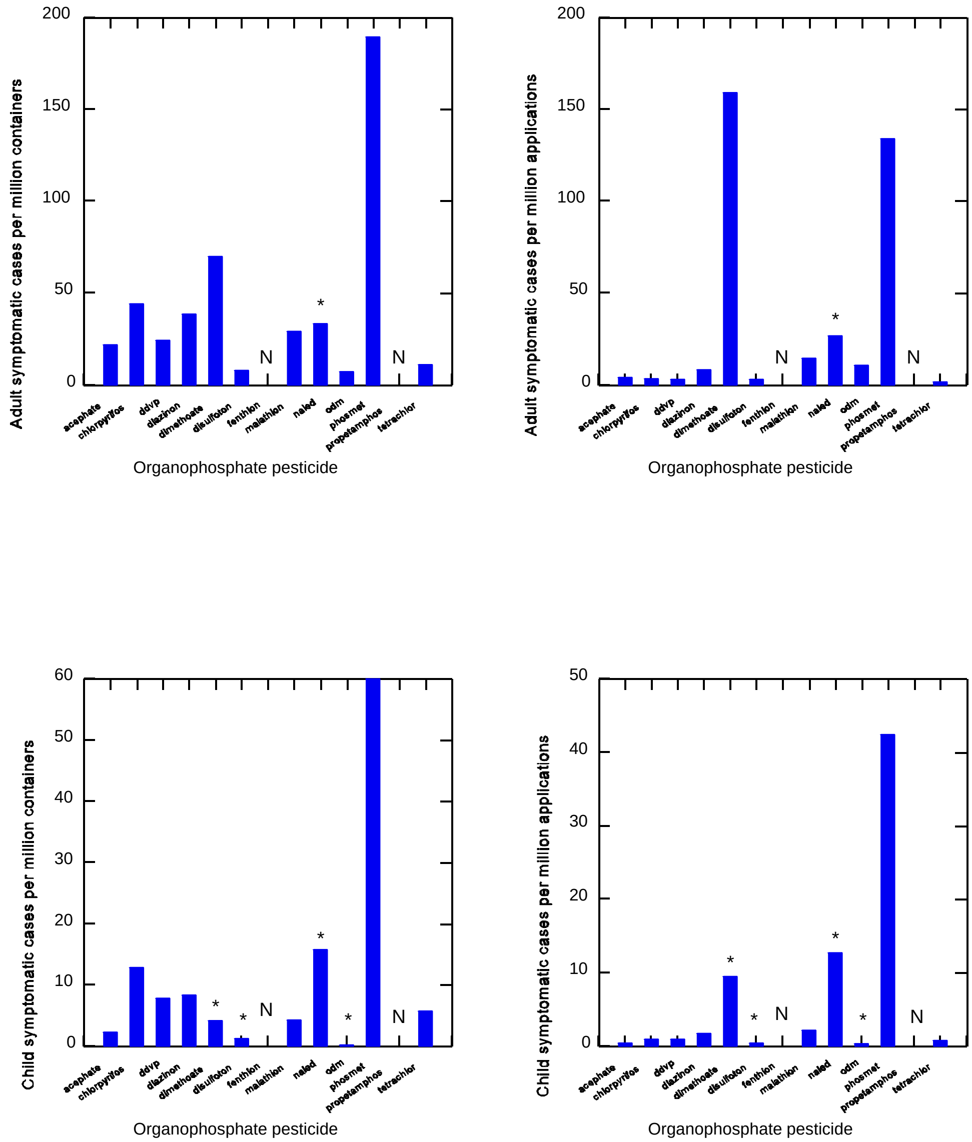

Figure 3. Ratio of residential symptomatic cases in children and adults per million containers (on left) and per million application (on right) in U.S. homes (* indicates too small sample size, N indicates no data). Based on Table 6.

Kline surveys of consumer use were consulted to determine whether trend in use since 1990 might explain unusually high or low ratios in Table 6 (Kline and Company 1990, 1994, 1996). Data were available only for the top 3 organophosphates, chlorpyrifos, diazinon, and malathion, for the years 1989, 1993, and 1995. Estimated pounds used did not differ by more than 10% for these three insecticides between 1989 and 1995. Overall use of insecticides, including the subcategories household and outdoor use, did not change by more than 10% from 1989 to 1995, which suggests little change occurred for most insecticides over this time period. Therefore, change in consumer use over the 1990 to 1996 time period is not a likely factor influencing the ratios in Table 6.

Another possible influence on Table 6 are products applied by Pest Control Operators in residential settings instead of by homeowners or consumers. Kline surveys of Pest Control Operators (PCO) use were consulted for the years 1991, 1993, and 1995 (Kline and Company 1992, 1994, 1996). Data for individual active ingredients are reported for four organophosphates, chlorpyrifos, diazinon, malathion, and propetamphos. These four accounted for 77% of the PCO insecticide use in 1991, but only 33% of the use in 1995. Most of the decline was due to chlorpyrifos and diazinon which together accounted for 74% of the 1991 use and 26% of the 1995 use. Malathion and propetamphos had substantial increases (three and two-fold increases, respectively) in reported use from 1991 to 1995 but they account for a relatively small percentage (7%) of the total insecticide use. Therefore, it appears unlikely that changes in PCO use over the 1990 to 1996 time period could have markedly affected the results presented in Table 6. A separate analysis of PCO products is presented, starting on page 19.

Table 7. Percent of residential exposures, symptomatic cases, and cases with serious outcome (moderate, major or fatal outcome) due to exposure to environmental residues reported to PCCs, 1993-1996. (Percents in shadow based on less than 25 cases in the denominator)

PESTICIDE	Percent environmental residue cases of:		
	Exposures	Symptomatic	Serious outcome
ACEPHATE	20%[3]	24%	43%[1]
CHLORPYRIFOS	15%	24%	30%[3]
DDVP	11%	15%	24%
DIAZINON	17%	20%	22%
DIMETHOATE	19%	26%[2]	27%
DISULFOTON	8.4%	20%	20%
FENTHION	3.0%	1.7%	17%
MALATHION	21%[2]	24%	30%
NALED	8.7%	10%	25%
OXYDEMETON METHYL	18%	25%[3]	20%
PHOSMET	4.0%	5.7%	11%
PROPETAMPHOS	33%[1]	41%[1]	33%[2]
TETRACHLORVINPHOS	3.5%	5.6%	8.7%
MEDIAN 13 OPs	15%	20%	24%
MEAN ALL OPs	13%	18%	25%
MEAN NON-OPs	5%	9%	15%

Top 3 chemicals are ranked with a superscript of 1 to 3.

One measure of a pesticide's potential hazard is the frequency of cases due to exposure to residues left after application or use. The category environmental exposure is used by Poison Control Centers to capture this kind of hazard. Organophosphates are nearly three times (13% versus 5%) more likely to be involved in environmental exposures than non-organophosphate pesticides. And, a larger proportion of the more serious cases are due to environmental exposures than the less serious cases. For organophosphate cases with a moderate, major, or fatal outcome, one-quarter of them are due to environmental exposures. Especially high in this category were acephate, propetamphos, and chlorpyrifos.

Table 8. Number and percent of symptomatic (medical outcome minor, moderate, or major) residential cases reporting effects lasting longer than one week or longer than one month, PCCs 1993-1996.

PESTICIDE	Duration of effects reported lasting longer than: One week		One month	
	number	percent	number	percent
ACEPHATE	10	2.3%[2]	1	0.23%
CHLORPYRIFOS	120	3.1%[1]	34	0.89%[2]
DDVP	15	1.3%	6	0.52%
DIAZINON	64	2.2%[3]	19	0.64%
DIMETHOATE	1	1.1%	0	0%
DISULFOTON	1	1.2%	0	0%
FENTHION	0	0%	0	0%
MALATHION	27	2.1%	9	0.70%[3]
NALED	0	0%	0	0%
OXYDEMETON METHYL	0	0%	0	0%
PHOSMET	2	0.5%	0	0%
PROPETAMPHOS	1	1.8%	1	1.8%[1]
TETRACHLORVINPHOS	1	0.6%	0	0%
MEDIAN FOR 13	242	1.2%	70	0%
MEAN ALL OPs	294	2.1%	85	0.61%
MEAN NON-OPs	802	1.3%	195	0.33%

Top 3 chemicals are ranked with a superscript of 1 to 3.

Another measure of potential hazard is the reported duration of effects once an individual develops symptoms. The number of cases reporting long-lasting effects was only 1-2 percent, but many cases do not receive sufficient follow-up to determine whether effects persist or new effects develop. Organophosphates are nearly twice as likely to have effects lasting longer than a week or longer than a month than are the non-organophosphate pesticides. Chlorpyrifos had the highest overall rate of persistent effects which is consistent with an earlier review of anecdotal reports (Blondell and Dobozy 1997). A detailed examination of the 120 chlorpyrifos cases with persistent effects found 41% were due to environmental exposures, 90% were adults or older children (6-19 years old), 63% were women, and the most common symptom category reported was neurological, also consistent with earlier reports.

Pest Control Operator products

EPA's surveyed certified and commercial pesticide applicators in five non-agricultural categories (structural, turf and ornamental, public health, right-of-way, and aquatic) in 1993. A total of 69 million pounds of active ingredient were estimated in use including 14.4 million pounds of organophosphate insecticides or 20.8% of the total. Over 90% of the organophosphate insecticide use is accounted for by just three active ingredients: chlorpyrifos (54%), malathion (30%), and diazinon (7%). Other organophosphates with some reported PCO use that were among the 13 insecticides with significant reporting to Poison Control Centers were acephate (3% of the total organophosphate use), propetamphos (0.6%), DDVP (0.1%), and oxydemeton methyl (0.1%). Kline (1994) surveys collected for the same year show similar results, except that much smaller use is reported for malathion (only 12% of the amount estimated in EPA's survey) and much higher use of propetamphos (2.3 times the amount reported by the EPA survey). Part of the disparity with malathion may have been differential reporting for mosquito abatement or medfly uses which require heavy poundage and changes dramatically from one year to the next.

For the purposes of estimating hazard of PCO use and homeowner or consumer use, products in the AAPCC database were divided into whether they were likely to be used by PCOs or homeowners. Unfortunately many products may be used by both consumers and PCOs. This was especially true for malathion where nearly all of the products reported in use by PCOs were also available for homeowner use. As a result, it was not possible to develop lists of both homeowner and PCO products for malathion. For the other top four organophosphates used by PCOs, chlorpyrifos, diazinon, acephate and propetamphos, it was possible. A total of 61 products in the AAPCC were identified as more likely to be used by commercial applicators than consumers based on the 1993 survey of PCOs, reports from Dow Agrosciences on which chlorpyrifos products were used primarily by PCOs, and Kline reports of PCO use. Data for these 61 products were compared with over 600 other products for these four organophosphates that were involved in residential incidents.

Undoubtedly some misclassification occurred with products in both lists. For example, some of the 'residential' incidents involve agricultural uses not intended for home use. However, the overwhelming majority of incidents were due to products commonly used by homeowners and therefore the small number of incidents involved in misclassification are not expected to unduly influence the results. Table 9 reports the number of incidents on which calculations are based for all four organophosphates. Tables 10 and 11 present the calculations for children under age six and adults and children over age 6 respectively.

Table 9. Number of cases of exposure, symptomatic cases (major outcome and fatal cases listed in parentheses), seen in a health care facility (HCF), or hospitalized (with cases admitted for intensive care (ICU) in parentheses) for 61 products used by Pest Control Operators and over 600 products more likely to be used by homeowners in a residential setting by age class.

Product type/ Age Group	Exposures	Symptomatic (Life-thr.)	HCF	Hospital. (ICU)
PCO/Child	444	81 (4)	107	25 (13)
Non-PCO/Child	9761	943 (11)	1074	127 (53)
PCO/Adult	1168	400 (2)	282	31 (14)
Non-PCO/Adult	8587	3016 (15)	1604	139 (61)

Table 10. PCO compared with non-PCO use of acephate, chlorpyrifos, diazinon, and propetamphos by percent residential cases seen in a HCF, percent hospitalized (of those seen in a HCF), percent ICU, percent with related symptoms (where outcome was known), and percent with major (life-threatening or residual disability) or fatal medical outcome for children under age six, PCCs 1993-1996.

Pesticide Type	% seen in a HCF	% Hospit-alized/ICU	% with symptoms	% major or fatal
PCO Use	24.1	23.4/12.1	35.1	1.73
Non PCO Use	11.0	11.8/4.9	19.4	.23
Ratio PCO/Non-PCO	2.2	2.0/2.5	1.8	7.5

Table 11. PCO compared with non-PCO use of acephate, chlorpyrifos, diazinon, and propetamphos by percent residential cases seen in a HCF, percent hospitalized (of those seen in a HCF), percent ICU, percent with related symptoms (where outcome was known), and percent with major (life-threatening or residual disability) or fatal medical outcome for adults and children six years and older, PCCs 1993-1996.

Pesticide Type	% seen in a HCF	% Hospit- alized/ICU	% with symptoms	% major or fatal
PCO Use	24.1	11.0/5.0	76.8	.38
Non PCO Use	18.7	8.7/3.8	69.9	.35
Ratio PCO/Non-PCO	1.3	1.3/1.3	1.1	1.1

Tables 9 and 10 show a much greater risk for children under six years of age exposed to products used by PCOs and containing either acephate, chlorpyrifos, diazinon, or propetamphos. For each of the four individual pesticides, where the percent was based on 25 or more observations, the percent was almost always higher for the PCO products than for the non-PCO products for both adults and children. Note that the number of cases involving these PCO products is relatively small compared to consumer products. Of the total 10,205 exposures involving children under age six, just 4% were due to products known to be used primarily by PCOs. For adults and children over six, 12% of the 9,755 exposures examined involve PCO products.

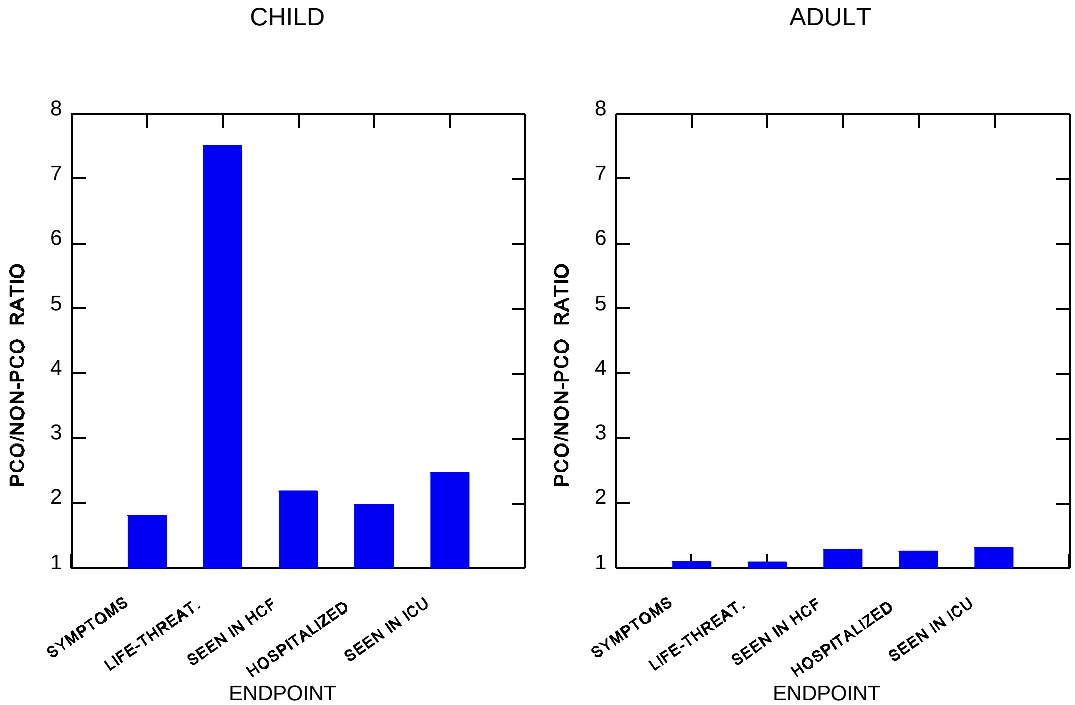

Figure 4. Ratio of PCO products to non-PCO products for the endpoints: percent symptomatic cases, percent with life-threatening or fatal effects, percent seen in a health care facility, percent hospitalized, and percent seen in an intensive care unit for both children under age six and adults and older children. Note that the high ratio for life-threatening/fatal category in children is based on just four PCO cases and 11 non-PCO cases.

Duration of effects was considered for PCO products but there were too few observations except for chlorpyrifos. Neither acephate, diazinon, or propetamphos had more than two cases with symptomatic effects lasting longer than one week. However, for chlorpyrifos there were 26 cases, 24 of which were due to a single PCO product. Of the 149 symptomatic cases from exposure to this product, 7.9% had symptoms persisting more than one week (6 times higher than non-organophosphates) and 2.7% had symptoms persisting longer than one month (20 times higher than non-organophosphates).

There was an average of 400 exposures per year reported for adults and children involving PCO products containing acephate, chlorpyrifos, diazinon, and propetamphos. Though the number of exposures is relatively small, the increased risk of serious effects requiring hospitalization and admission for critical care is significant.

A preliminary analysis of selected pyrethroid insecticides was performed to see whether products used primarily by PCOs exhibit the same pattern as described above for organophosphates. The nine pyrethroid products selected contained either cyfluthrin, cypermethrin, or permethrin and had close to the same number of exposures reported for PCO products in both children and adults as did the four organophosphates. Like the four organophosphates, the selected pyrethroids had higher measures of hazard in all categories (except for children admitted to an ICU which was lower for the PCO products) when compared to predominantly non-PCO pyrethroids in both adults and children. When the four PCO organophosphates were compared with the three PCO pyrethroids, the organophosphates had higher percentages of hospitalization and admission for critical care in adults and children and higher percent case classified as life-threatening or fatal in children under age six. The selected PCO-pyrethroids had higher percent life-threatening cases in adults and slightly higher percent symptoms and health care facility use in both adults and children.

IV. <u>SUMMARY AND DISCUSSION</u>

Organophosphate pesticides pose a greater hazard from exposure than do other pesticides, especially for children under six years of age. Children were three times more likely to be hospitalized, five times more likely to be admitted for critical care, and four times more likely to have experienced a major medical outcome or death than if exposed to some other pesticide (see Figure 5). For adults and older children the differences were not nearly so dramatic, though adults were 50% more likely to be admitted for hospitalization and nearly twice as likely to require treatment in an intensive care unit. On the other hand, adults and older children exposed to organophosphates were just as likely to develop symptoms, including symptoms that were life-threatening or led to a fatal outcome, as adults exposed to other pesticides.

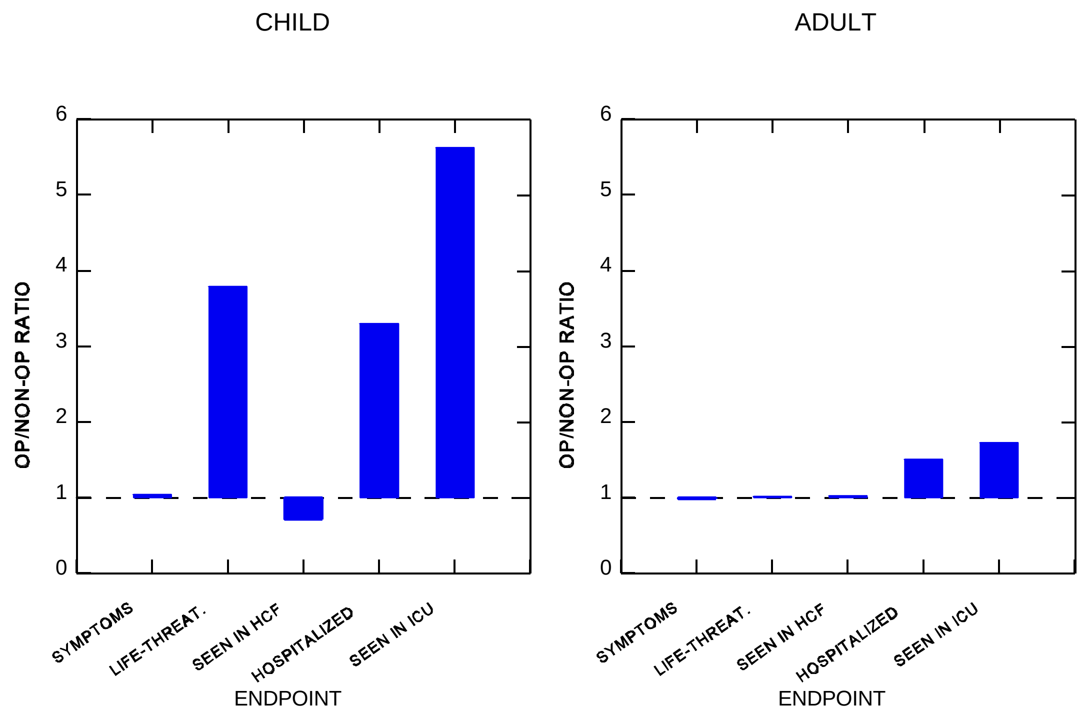

Figure 5. Ratio of organophosphate pesticides to all other pesticides (non-organophosphates) for the endpoints: percent symptomatic cases, percent with life-threatening or fatal effects, percent seen in a health care facility, percent hospitalized, and percent seen in an intensive care unit for both children under age six and adults and older children.

Figures 6 and 7 compares organophosphates with other types of pesticides (see coding in Table 12) on selected measures. Figure 6 covers measures for young children and Figure 7 provides the same information for adults and older children. The two top bargraphs in each figure give the number of symptomatic cases and the number of life-threatening or fatal outcomes. The two bottom bargraphs in each figure give the percent of cases (where outcome was known) that were life-threatening or fatal and the percent of cases seen in a health care facility that were admitted to a critical care unit (ICU). For children, organophosphates ranked fourth for number of symptomatic cases, first for life-threatening or fatal case, second for percent life-threatening or fatal cases, and first for percent seen in an ICU. Similarly for adults, organophosphates ranked first for number of symptomatic cases and cases that were life-threatening or fatal, seventh for percent life-threatening cases, and first for percent cases seen in an ICU.

Table 12. Coding used in Figures 6 and 7 for pesticide types.*

Figure abbreviation	Meaning
DISINFPHENOL	Disinfectants containing phenols
DISINF_HYPOC	Disinfectants containing hypochlorites
DISINF_OTHER	Other types of disinfectants
DISINF_PINE	Disinfectants containing pine oil
FUMIGANT	Self explanatory
FUNGICIDE	Self explanatory
HERBICIDE	Self explanatory
INSECT_BORIC	Insecticides containing boric acid/borates
INSECT_CB	Insecticides containing carbamates
INSECT_OC**	Insecticides containing organochlorines
INSECT_OP	Insecticides containing organophosphates
INSECT_OTHER	Other types of insecticides
INSECT_PY	Insecticides containing pyrethrins or pyrethroids
INSECT_REPEL	Insect repellents
MOTH_REPEL	Moth repellents
RODENT_ANTI	Anticoagulant rodenticides
RODENT_OTHER	Other types of rodenticides

*Insecticides containing more than one type of insecticide are categorized hierarchically: organophosphate, carbamates, organochlorines, and pyrethrins/pyrethriods. This means, for example, that any product containing an organophosphate and a pyrethroid will be classified as an organophosphate. Similarly, any product containing a carbamate and an organochlorine would be categorized as a carbamate.

** The majority of organochlorines cases involve lindane products used to treat head lice, which are regulated by FDA, not EPA. Eliminating such products would lower the severity measures for this group. So, in Figure 6 for example, organophosphates are both the most frequent cause of life-threatening or fatal poisonings and responsible for the highest percentage of cases with a medical outcome of life-threatening or fatal in young children for any pesticide type regulated by EPA.

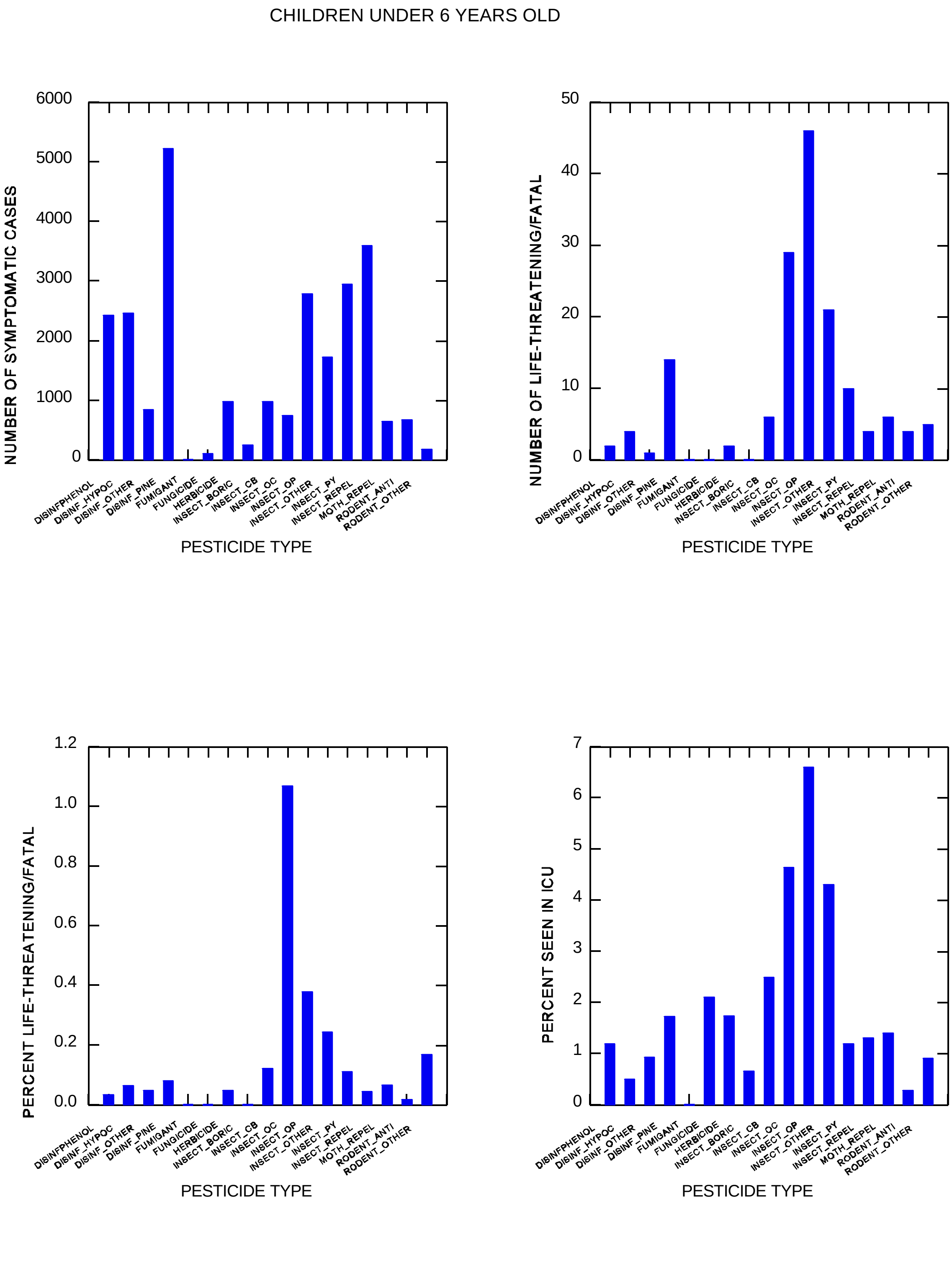

Figure 6. Number of symptomatic cases, number of life-threatening

or fatal cases, percent life-threatening/fatal, and percent seen in an ICU for children less than six years old, 1993-1996.

ADULTS AND CHILDREN 6-19 YEARS OLD

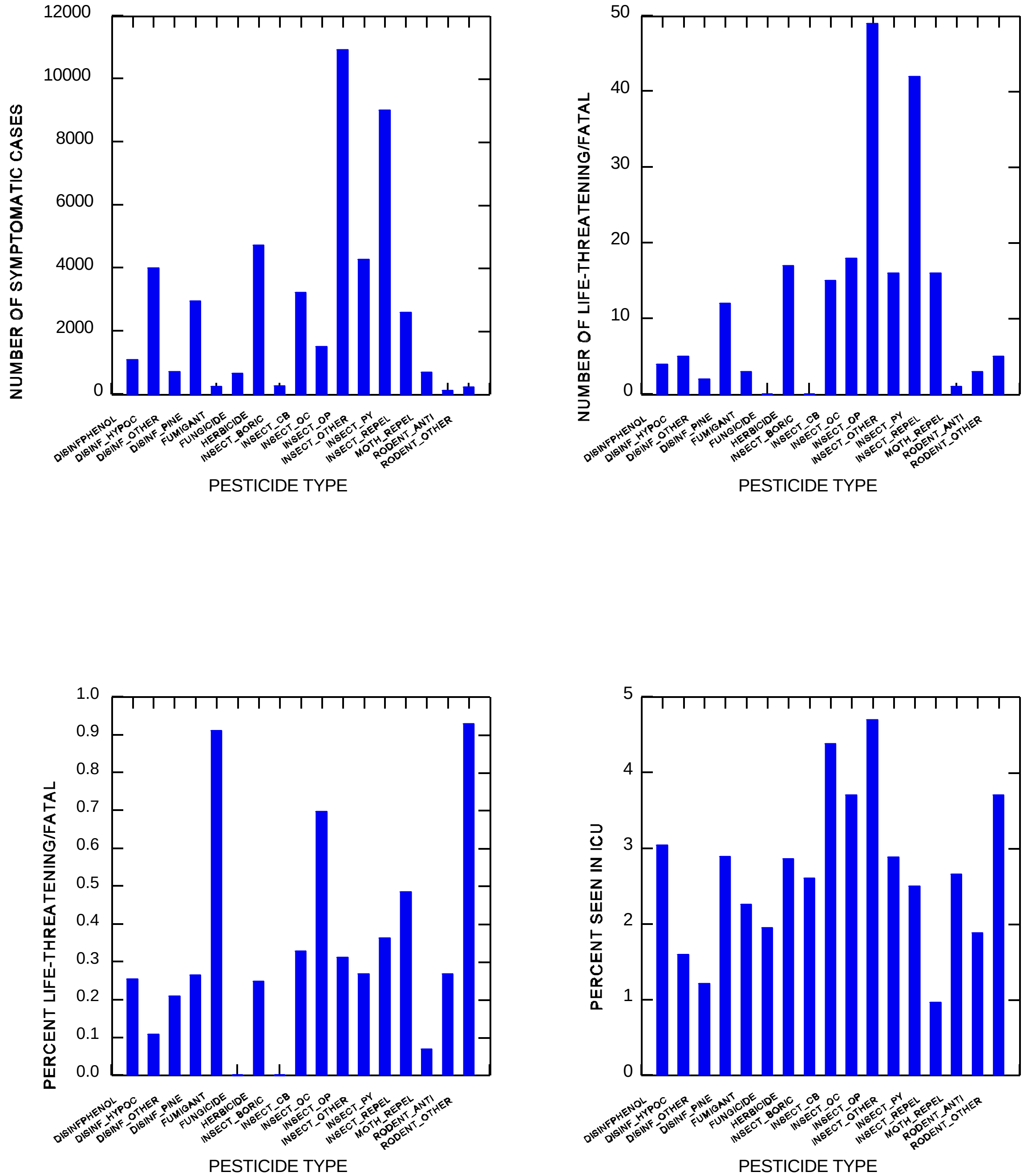

Figure 7. Number of symptomatic cases, number of life-threatening or fatal cases, percent life-threatening/fatal, and percent seen in an ICU for adults and older children (6-19 years), 1993-1996.

One crude way to get an idea of the hazard from a particular organophosphate is to tally the number of times it ranks in the top 3 for Tables 3-8, excluding those measures that were unreliable due to small sample size. On average, by chance each product would rank in the top 3 on four out of the 19 rankings. There were four products that ranked in the top three on five or more occasions: Phosmet ten times; propetamphos 7 times; chlorpyrifos 7 times; and dimethoate 5 times. These high rankings are summarized below.

Phosmet ranked 1st for health care facility use, 3rd for hospitalization, and 2nd for symptoms in children (Table 3). Phosmet ranked 1st for health care facility use and 2nd for hospitalization for adults (Table 4). It ranked 1st for ICU use in children (Table 5). Phosmet ranked 1st for ratio of poisoning per million containers and per million applications for children and per million containers for adults and it ranked 2nd per million applications for adults (Table 6).

Propetamphos ranked 2nd for health care facility use and 1st for symptoms and major/fatal outcome for children (Table 3). Propetamphos ranked 2nd for symptoms in adults (Table 4). Propetamphos ranked 1st for proportion of exposures and symptomatic cases that were due to environmental residue (Table 7) and first for cases having duration of effects longer than one month based on a single case (Table 8).

Chlorpyrifos ranked 3rd for symptoms and 1st for major/fatal outcome reported in adults (Table 4). Chlorpyrifos ranked 3rd for ratio of symptoms per containers reported in US homes for both children and adults (Table 6). Chlorpyrifos ranked 3rd for serious outcomes from environmental residues (Table 7). Chlorpyrifos ranked 1st for effects persisting longer than a week and second for effects lasting longer than a month (Table 8).

Dimethoate ranked 3rd for health care facility use in both children and adults (Tables 4 and 5). The ratio of dimethoate poisonings per million containers ranked 2nd in adults, while the ratio per million applications in adults ranked 1st (Table 6). The proportion of symptomatic cases due to environmental residues ranked second for dimethoate (Table 7).

When acephate, chlorpyrifos, diazinon, and propetamphos products are divided into PCO and non-PCO uses, there is always a greater hazard from the PCO products than non-PCO products, especially for young children. Although the number of cases appears relatively small, the increased hazard is significant. Part of this increased hazard results from exposure to higher toxicity concentrates and part is due to careless, poorly supervised, and/or poorly trained PCOs. Though the overwhelming majority of PCOs may apply organophosphates properly in a manner that does not result in risks to residents, there are a small number of PCOs that mishandle or misapply products leading to the differences observed in this study.

Phosmet appears to pose a greater risk to children than other organophosphate insecticides on account of the primary manner in which it is sold, a 12 percent concentrate that must be diluted 128-fold before being used as a pet dip for dogs. Based on estimated oral toxicity in animals, 1 swallow or 1 teaspoon of phosmet concentrate ingested by a 10 kg one-year old child would be a lethal dose.

Propetamphos ranks high and this may be related to problems associated with exposure to residues and inappropriate use by Pest Control Operators.

Symptomatic chlorpyrifos cases were more likely to experience effects lasting longer than one week or even one month. This finding is consistent with an earlier review that suggested that chlorpyrifos may be a cause of chronic neurobehavioral effects in some subset of sensitive people who have been poisoned by this compound (Blondell and Dobozy 1997). The types of effects chronic effects commonly reported include non-specific symptoms which may go unnoticed and unreported. The most common complaints include persistent headaches, blurred vision, muscle weakness, and problems with memory, concentration, confusion, depression, and irritability.

V. RECOMMENDATIONS

1. Organophosphate concentrates in Toxicity Categories I and II used by PCOs should be classified for restricted use. The purpose is to assure that PCOs handling these products are trained concerning their hazards and are aware of the need for close supervision of applicators in residential settings. A similar restriction may be needed for pyrethroids.

2. Due to the increased hazard to children, it is recommended that all liquid and solid granular and dust formulations be placed in child-resistant packaging. This requirement would not apply to impregnated materials such as flea collars.

3. A follow-up study of symptomatic organophosphate cases should be conducted to determine the prevalence, persistence, and severity of chronic effects. Anecdotal reports and the data on duration of effects from Poison Control Centers suggest that a sensitive subset of the population is developing non-specific neurobehavioral effects. Evidence that odor and petroleum-related carriers contribute to these effects should be considered.

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Appendix Table 1. Number of unintentional residential exposures, symptomatic cases, cases seen in a health care facility, or hospitalized among children under six years reported to PCCs, 1993-1996 (includes only exposures to single products).

PESTICIDE	Expo-sures	Sympto-matic	Outcome known	Seen in HCF	Hospit-alized
ACEPHATE	348	41	188	50	3
CHLORPYRIFOS	8998	858	4318	993	125
DDVP	2345	280	1198	233	25
DIAZINON	4253	524	2516	769	128
DIMETHOATE	44	5	23	10	5
DISULFOTON	236	12	147	23	5
FENTHION	64	4	48	10	2
MALATHION	1352	164	785	248	40
NALED	89	10	47	10	1
OXYDEMETON METHYL	19	1	12	2	1
PHOSMET	470	89	362	204	45
PROPETAMPHOS	63	11	32	19	2
TETRACHLOR-VINPHOS	495	56	268	24	2

SUBTOTAL	18,776	2055	9944	2595	384
TOTAL ALL OP	24,889	2795	12,164	3,164	482
TOTAL NON-OP	212,321	23,868	108,240	37,844	1748

Appendix Table 2. Number of unintentional residential exposures, symptomatic cases, cases seen in a health care facility, or hospitalized among adults and children six years and older reported to PCCs, 1993-1996 (includes only exposures to single products).

PESTICIDE	Expo-sures	Sympto-matic	Outcome known	Seen in HCF	Hospit-alized
ACEPHATE	1208	388	570	259	23
CHLORPYRIFOS	8562	2945	3946	1760	168
DDVP	2962	866	1262	436	33
DIAZINON	7398	2420	3574	1502	163
DIMETHOATE	251	84	127	52	4
DISULFOTON	322	73	135	45	6
FENTHION	202	55	91	26	4
MALATHION	3797	1111	1827	660	69
NALED	60	21	26	12	0
OXYDEMETON METHYL	94	30	50	13	1
PHOSMET	772	281	432	196	27
PROPETAMPHOS	133	45	59	18	0

TETRACHLOR-VINPHOS	301	105	153	39	1
SUBTOTAL	26,062	8,424	12,252	5,018	499
TOTAL ALL OP	37,167	10,938	15,747	6,662	662
TOTAL NON-OP	114,177	36,392	51,438	20,099	1332

Appendix Table 3. 1990 National home and garden survey results for selected organophosphate insecticides (Whitmore et al 1992).

Active Ingredient	Survey Rank*	Products (1,000s)	Applications (1,000s)
Chlorpyrifos	10	16,652	216,222
Diazinon	12	15,703	74,369
Malathion	22	9,551	18,965
Dichlorvos	23	8,953	72,392
Acephate	34	4,490	24,589
Tetrachlorvinphos	49	2,423	17,702
Disulfoton	55	2,364	6,464
Oxydemeton methyl	77	1,032	715
Phosmet	121	371	524
Dimethoate	128	301	132
Naled	165	158**	197

* Survey ranking based on estimated number of products or containers in U.S. homes.

** Estimate has poor precision (relative standard error > 50%).
The majority of residential use associated with fenthion and propetamphos is by Pest Control Operators. There was no reported use of fenthion and the reported us for propetamphos was considered too low to provide a reliable estimate.

Appendix Table 4. Number of unintentional residential exposures, symptomatic cases, serious cases (cases with moderate, major, or fatal outcome) that are due to environmental exposure (exposure to residue or product not under direct control of victim) reported to PCCs, 1993-1996 (includes only exposures to single products).

PESTICIDE	Exposures	Symptomatic	Serious Outcome
ACEPHATE	314	104	24
CHLORPYRIFOS	2695	930	175
DDVP	565	175	35
DIAZINON	2046	590	104
DIMETHOATE	58	23	3
DISULFOTON	48	17	2
FENTHION	8	1	1
MALATHION	1088	311	55
NALED	13	3	1

OXYDEMETON METHYL	21	8	1
PHOSMET	50	21	7
PROPETAMPHOS	65	23	2
TETRACHLORVINPHOS	28	9	2
SUBTOTAL	6999	2215	412
TOTAL ALL OP	8065	2544	487
TOTAL NON-OP	17,725	5552	1073

OPs account for 32% of the environmental exposures occurring in residences but only 19% of the total home use.

cc: Correspondence
Jeff Evans (7509C)
chlorpyrifos file (#059101)
disulfoton file (#032501)
naled file (#034401)
dimethoate file (#035001)
malathion file (#057701)
diazinon file (#057801)
phosmet file (#059201)
tetrachlorvinphos file (#083701)
ddvp file (#084001)
acephate file (#103301)
propetamphos file (#113601)